NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION WATER CONVEYANCE NONREINFORCED CONCRETE DITCH AND CANAL LINING

(Ft)

CODE 428A

DEFINITION

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch, irrigation canal, or lateral.

SCOPE

This standard applies to concrete linings made of nonreinforced Portland cement concrete that is cast in place in a performed ditch or canal section but does not include linings of pneumatically applied mortar.

This standard is restricted to installations in ditches or canals that have a bottom width not greater than 6 ft, a design capacity not greater than 100 ft^3/s, and a maximum velocity of 15 ft/s.

This standard includes design and construction criteria for shaping or reshaping the ditch section as well as for the lining.

PURPOSE

To prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water loss.

CONDITIONS WHERE PRACTICE APPLIES

The lands served by the lined ditches or canals shall be suitable for use as irrigated land as identified in the North Dakota Irrigation Guide.

Ditches and canals to be lined shall serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Lined ditches and canals shall be located where they are not susceptible to damage from side drainage flooding, or they shall be protected from such damage.

Nonreinforced concrete linings shall be installed only in well-drained soils having less than 35% clay content or on sites where subgrade drainage facilities are installed with or before the lining. These linings shall not be installed on sites susceptible to severe frost heave or on sites where experience has indicated that the sulfate salt concentration in the soil causes rapid concrete deterioration. On sites where sulfate concentrations exist, concrete linings may be used only if they are made using special sulfate-resistant cement as follows:

Types of Cement Required for Concrete Exposed to Sulfate Attack

Percentage water-soluble Sulfate (as SO_4) in soil samples	Sulfate (as SO_4) in water samples, ppm	Cement type
0.00 to 0.10	0 to 150	I or IP
0.10 to 0.20	150 to 1,500	II, II w/Class F pozzolan[1] or IP (MS)[1]
0.20 to 2.0	1,500 to 10,000	V, V w/Class F pozzolan[2], II w/Class F pozzolan[2], or IP (MS)[2]
2.0 or more	10,000 or more	V plus Class F pozzolan[2]

[1]R factor less than 1.5 for substituted or blended cement.
[2]R factor less than 0.75 for substituted or blended cement, where $R = (CaO-5)/ Fe_2O_3$

Concrete shall have a minimum compressive strength of 3000 psi at the end of 28 days.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resource Conservation Service.

NRCS, ND
July 1987

DESIGN CRITERIA

Capacity. A lined ditch or canal shall have enough capacity to meet its requirement as part of the planned irrigation water distribution or conveyance system without damage of overtopping. Design capacity shall be based on the following, whichever is greatest.

1. Capacity shall be enough to deliver the water needed for irrigation to meet the design peak consumptive use of the crops in the area served.

2. Capacity shall be enough to provide an adequate irrigation system for all methods of irrigation planned for use in the area served.

3. For design purposes, the capacity shall be considered to be equal to the capacity as computed with the Manning Formula by using a coefficient of roughness n of not less than 0.015.

Velocity. To avoid unstable surge flows, restrict a design velocity in excess of 1.7 times the critical velocity to straight reaches that discharge into a section or structure designed to reduce the velocity to less than critical velocity. The maximum velocity in these straight reaches shall be 15 ft/s. The velocity in ditch reaches from which water is to be delivered onto the field through turnouts, siphon tubes, or to similar means shall be less than super-critical and sufficiently low to permit operation of the planned takeout structure or device.

Freeboard. The required freeboard varies according to the size of the ditch or canal, the velocity of the water, the horizontal and vertical alignment, the amount of the storm or waste water that may be intercepted, and the change in the water surface elevation that may occur when any control structure is operating. The minimum freeboard for any lined ditch or canal shall be 3 in. of lining above the designed water surface.

This minimum freeboard requirement is based on the assumption that the finished channel bottom elevation will vary no more than 0.1 ft from the design elevation. If a construction deviation greater than 0.1 ft is permitted, the minimum freeboard shall be increased.

More freeboard shall be provided if required by slope velocity, depth of flow, alignment, obstruction, curves, and other site conditions.

Water surface elevations. All lined ditches and canals shall be designed so that the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to be used to provide the necessary head, the backwater effect must be considered in computing freeboard requirements. The required elevation of the water surface varies with the type of takeout structure or device used and the amount of water to be delivered through each. A minimum head of 4 in. shall be provided.

Lining thickness. The thickness of canal linings must be established on the basis of engineering consideration on each job. Location, canal size, velocity, subgrade conditions, method of construction, operation, and climate shall be evaluated in establishing the thickness to be used. The minimum thickness for nonreinforced concrete linings in rectangular sections shall be 3 ½ in. For trapezoidal or parabolic sections, the minimum thickness shall be as shown in Table 1.

Ditch or canal side slopes Nonreinforced concrete linings generally are used in ditches and canals that have either trapezoidal or parabolic cross section.

They may be used in rectangular sections if the sidewall height is not greater than 1 ½ ft. Side slopes for usual construction methods shall not be steeper than shown below:

Hand-placed, formed concrete:
Height of lining less than 1 ½ ft.....Vertical

Hand-placed, screened concrete:
Height of lining less than 2 ½ ft .....3/4 to 1
Height of lining more than 2 ½ ft .....1 to 1

Slip form concrete:
Height of lining less than 3 ft.....1 to 1
Height of lining more than 3 ft.....1 ¼ to 1

Ditch or canal banks. Ditch and canal banks shall be built up with earth to at least the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than 2 in. above the top of the lining.

Banks and berms shall be wide enough to insure stability of fills and to prevent excessive deposition in cut sections.

If the bank or berm is to be used as a roadway, the minimum top width shall be adequate for the purpose.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability.

Related structures. Plans for installing ditch or canal linings shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for successful conservation irrigation. These structures can be installed before, during, or after placement of the lining. They must be constructed or installed in such a way as not to damage the lining or to impair its effectiveness.

Materials. All materials shall meet or exceed the minimum requirements indicated under specifications for "Materials."

Table 1. — Minimum required thickness for nonreinforced concrete ditch and canal linings

Design velocity[1]	Minimum thickness by climatic area[2]	
	Warm	Cold
ft/s	*in*	*in*
Less than 9.0	1.5	2.0
9.0 - 12.0	2.0	2.5
12.0-15.0	2.5	3.0

[1]Velocities in short chute sections shall not be considered design velocity.

[2]Climatic area:

Warm - Average January temperature is 40 °F and above

Cold - Average January temperature is less than 40 °F.

PLANS AND SPECIFICATIONS

Plans and specifications for installing nonreinforced concrete irrigation ditch and canal linings shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

PLANNING CONSIDERATIONS FOR WATER QUANTITY AND QUALITY

Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, and deep percolation and ground water recharge.

2. Effects on downstream flows or aquifers that would affect other water uses or users.

3. Potential use for irrigation water management.

4. Potential changes in growth and transpiration of vegetation located next to the conveyance because of the elimination of leakage from the system.

Quality

1. Effects of installing the lining on the erosion of the earth conveyance and the movement of sediment and soluble and sediment-attached substances carried by water.

2. Effects on the movement of dissolved substances to ground water.

3. Effects on wetlands or water-related wildlife habitats.

4. Effects on the visual quality of water resources.